

Source Control Early Action Focused Feasibility Study

Empirical Mass Balance Model Results
for the Lower Passaic River

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Malcolm Pirnie, Inc.

*Remedial Options Workgroup Meeting
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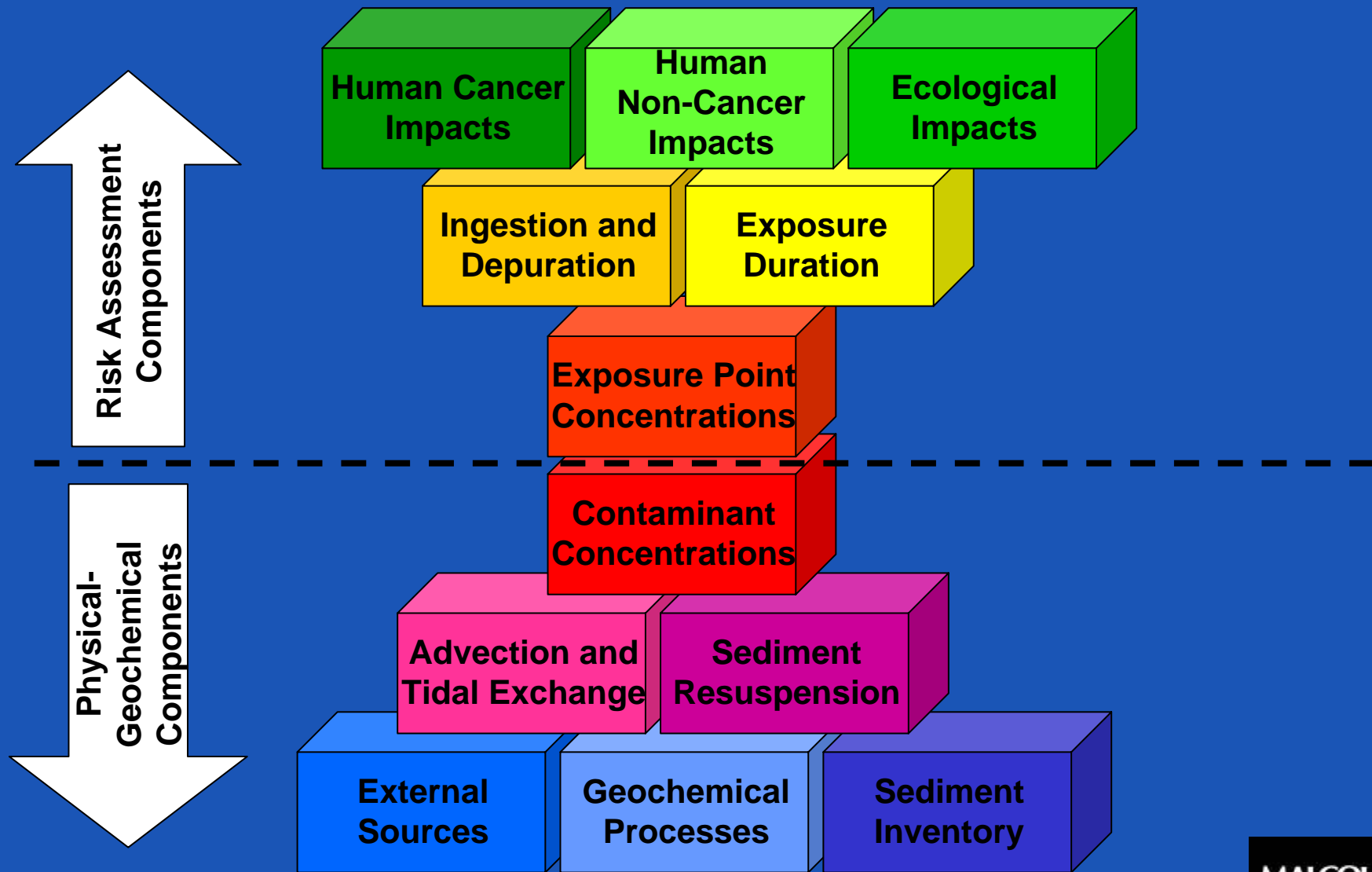
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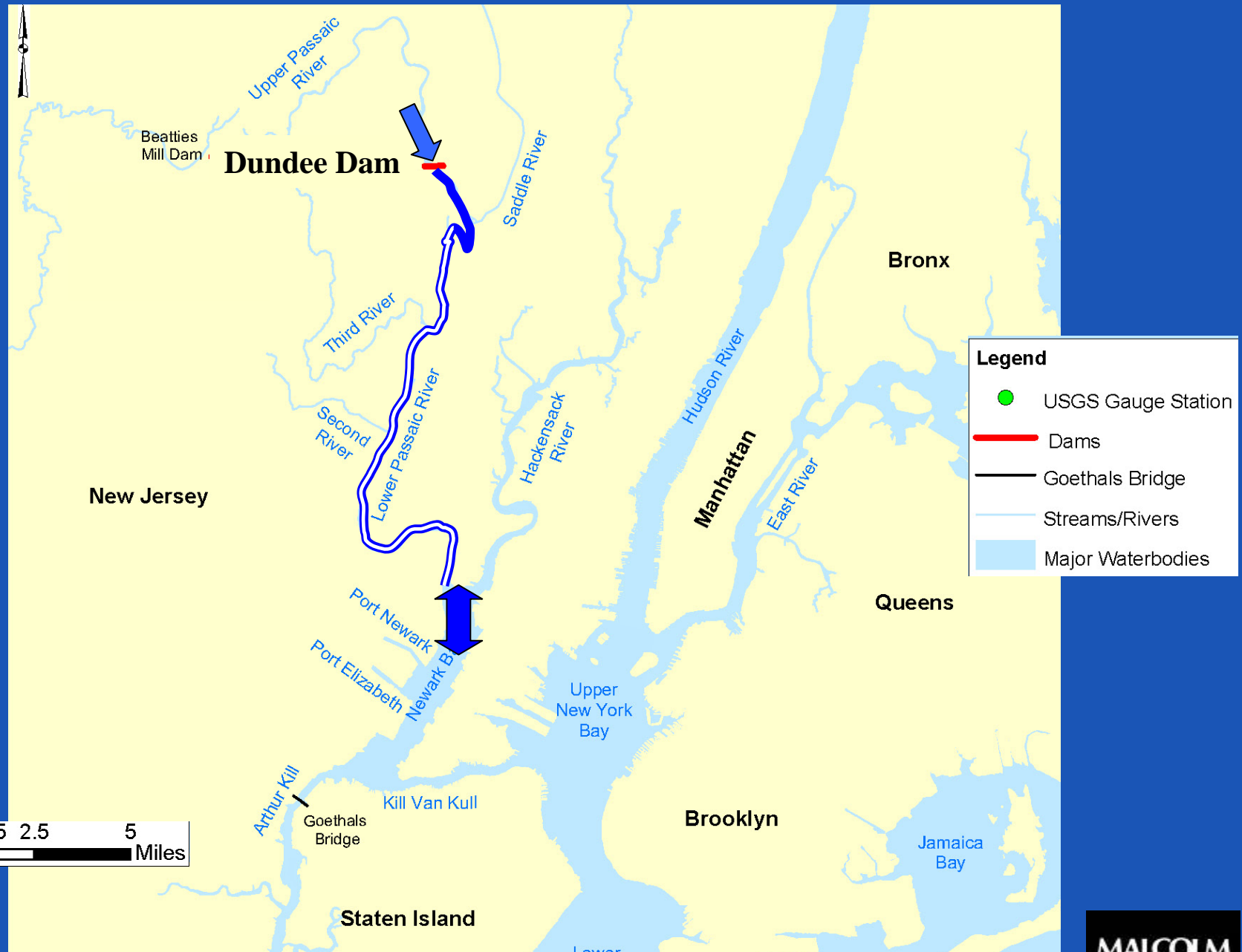
Outline

- Components of the Conceptual Site Model (CSM)
 - Physical-Geochemical Setting
 - Human and Ecological Setting
- Framework for the Empirical Mass Balance Model
- Mass Balance Results
- Historical Record and Remedial Scenario Forecasts
- Conclusions

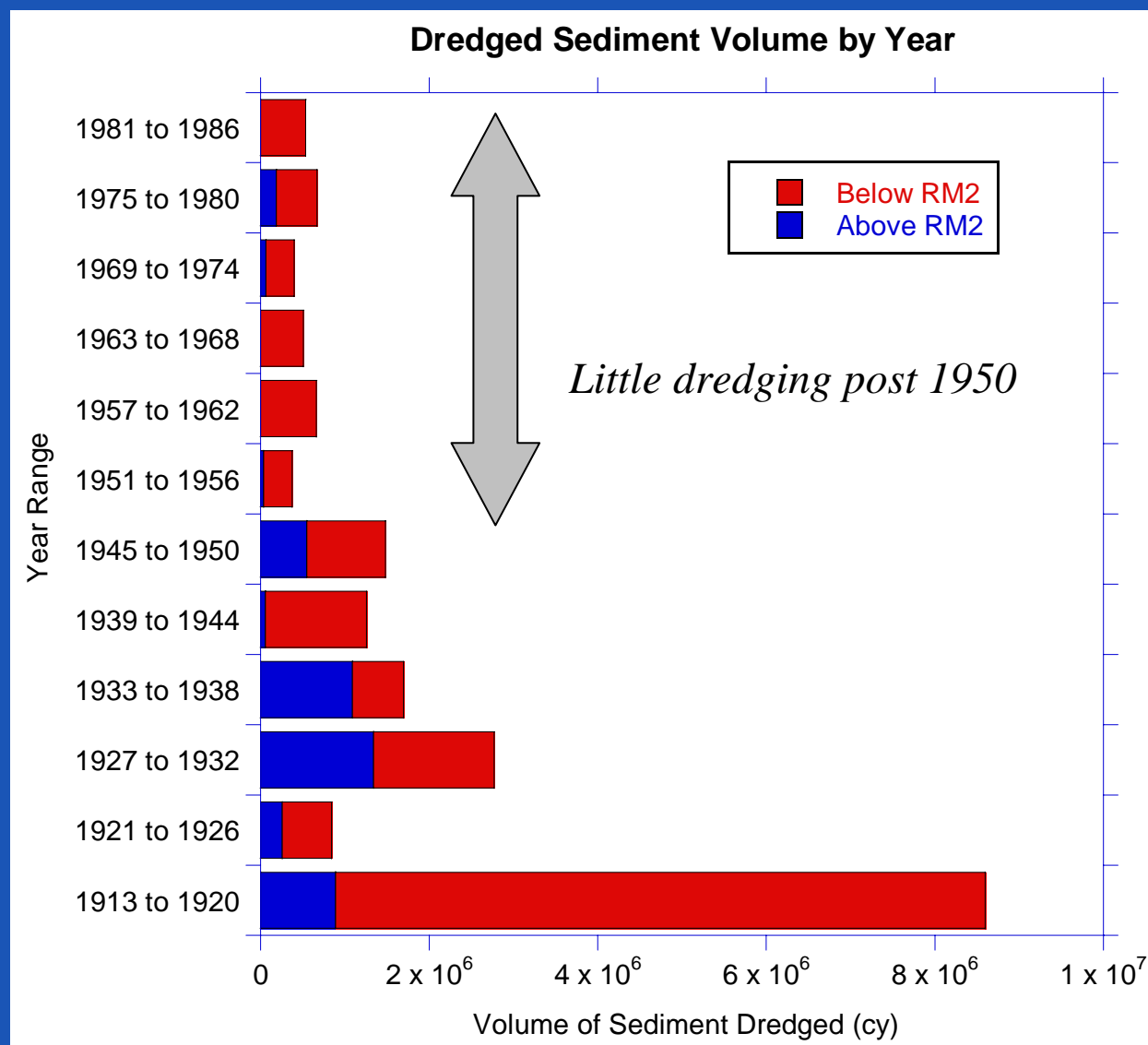


Components of the CSM

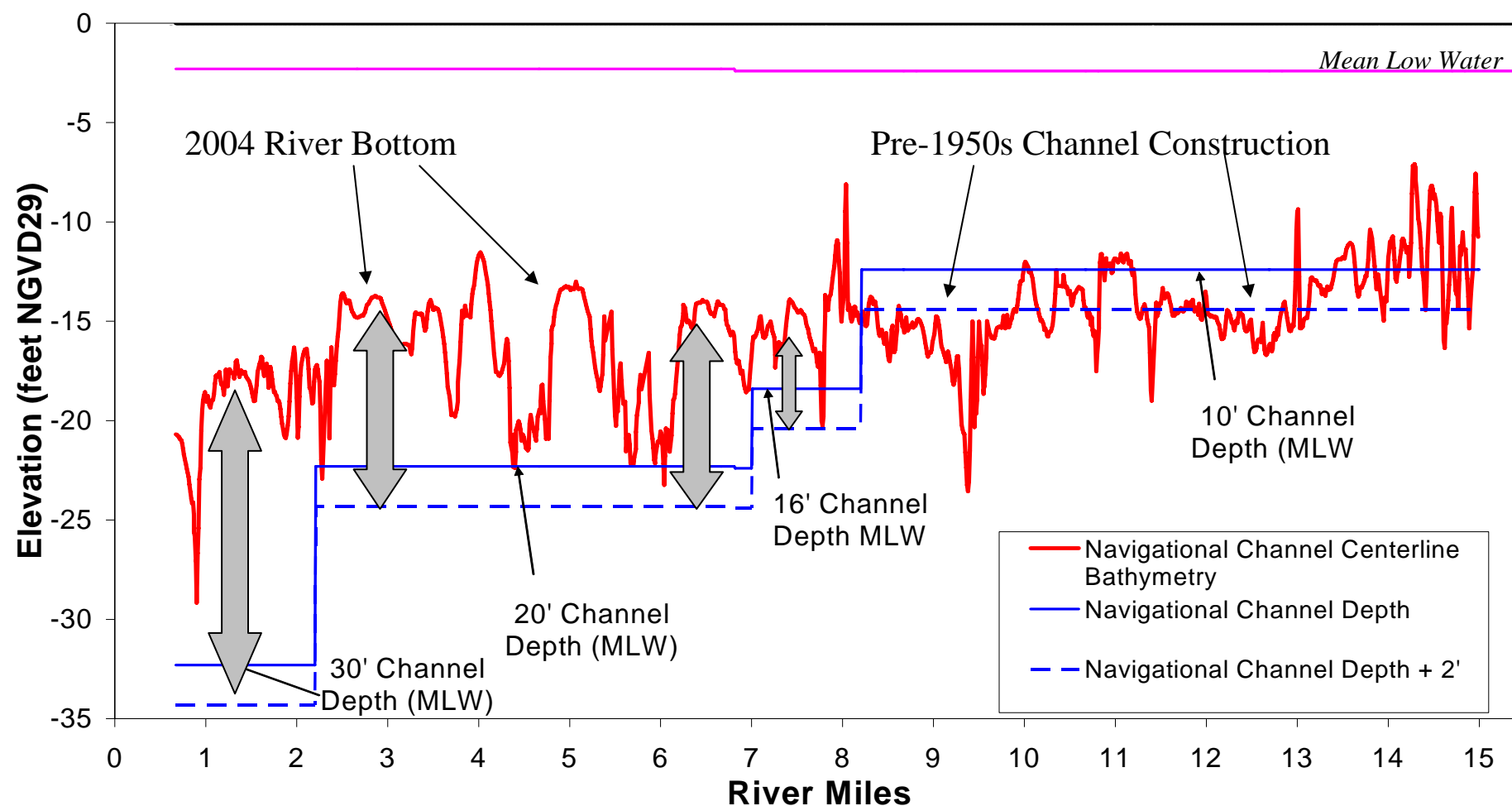




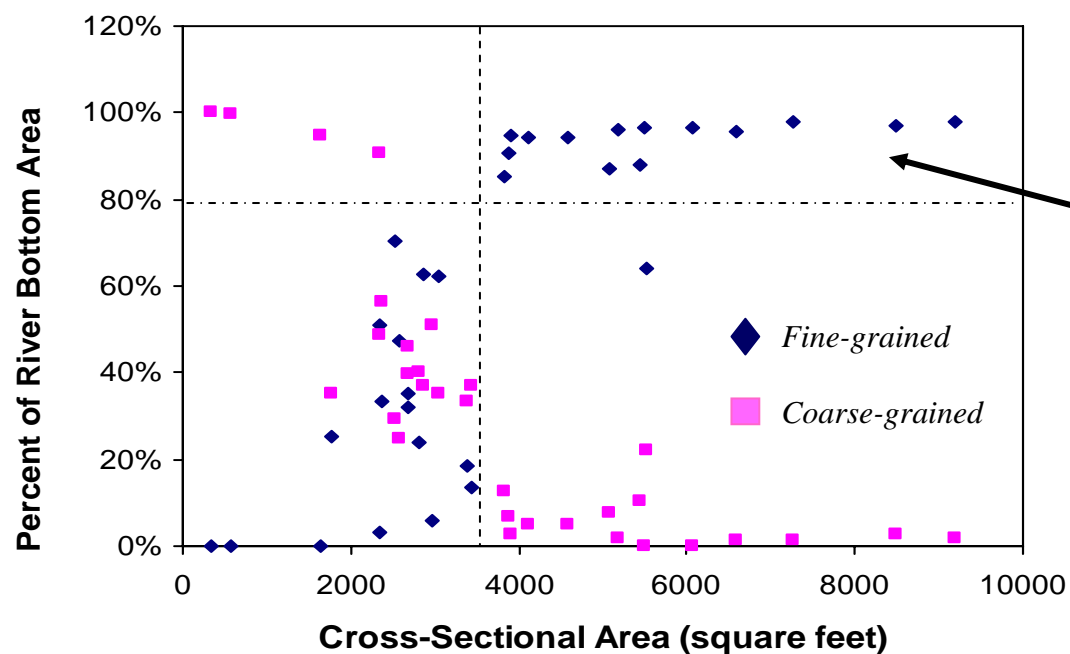
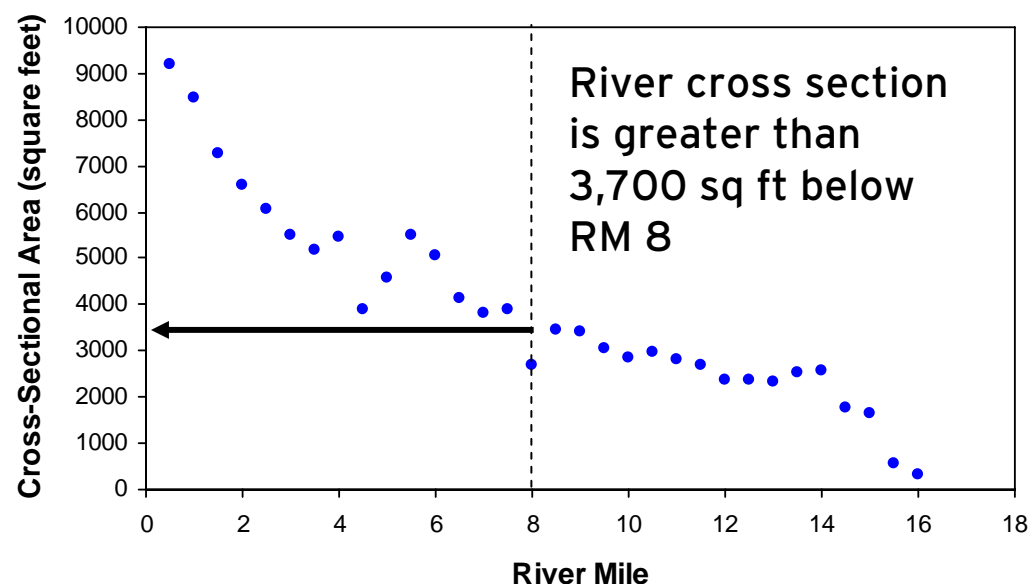
History of Dredging in the Lower Passaic



River Channel Elevation and the Constructed Depths of the Lower Passaic River Channel



Passaic River Cross Section and Sediment Type

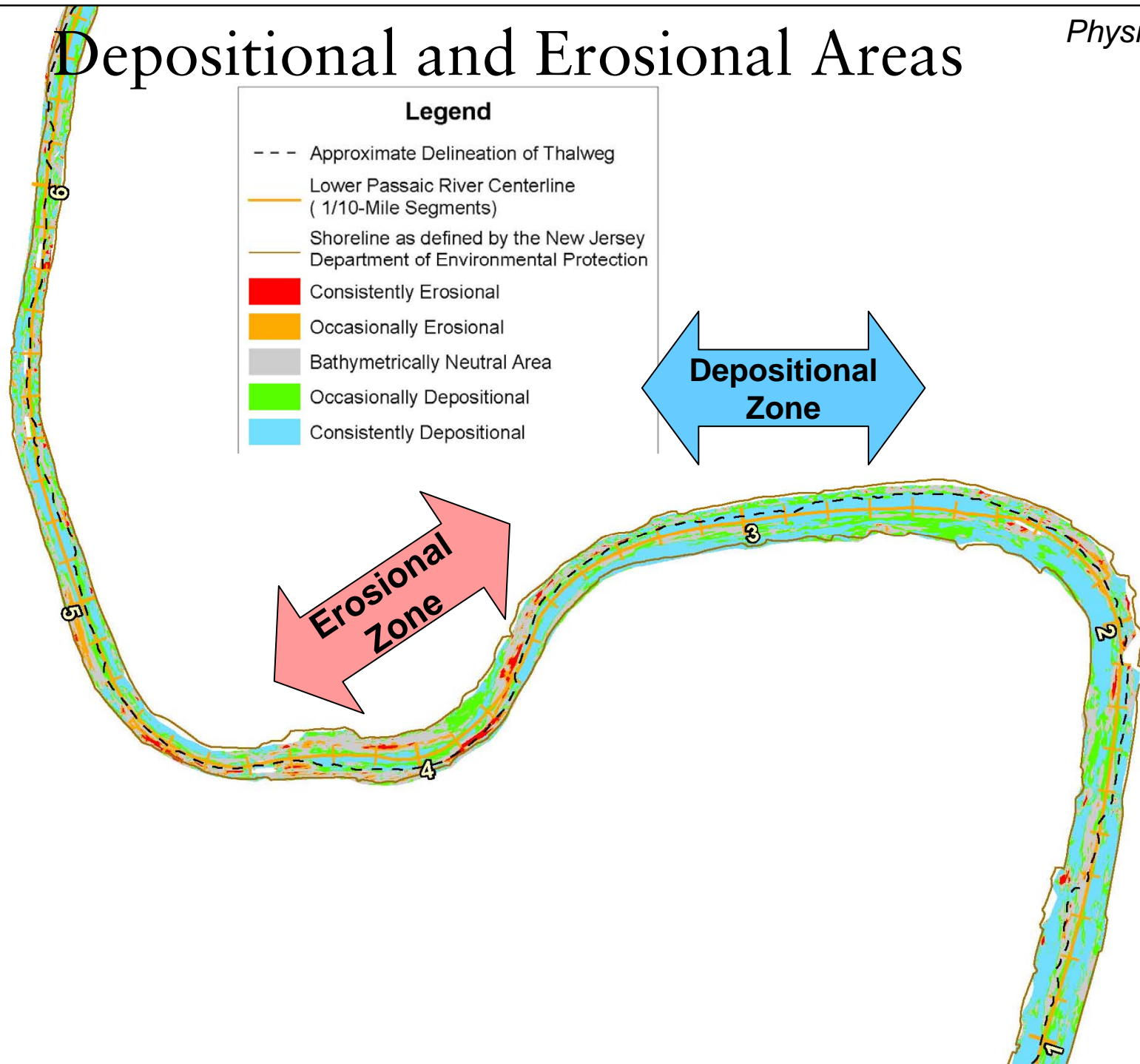


Fine-grained sediment covers 80% or more of the river bottom when the cross-sectional area is $>3,700$ sq ft

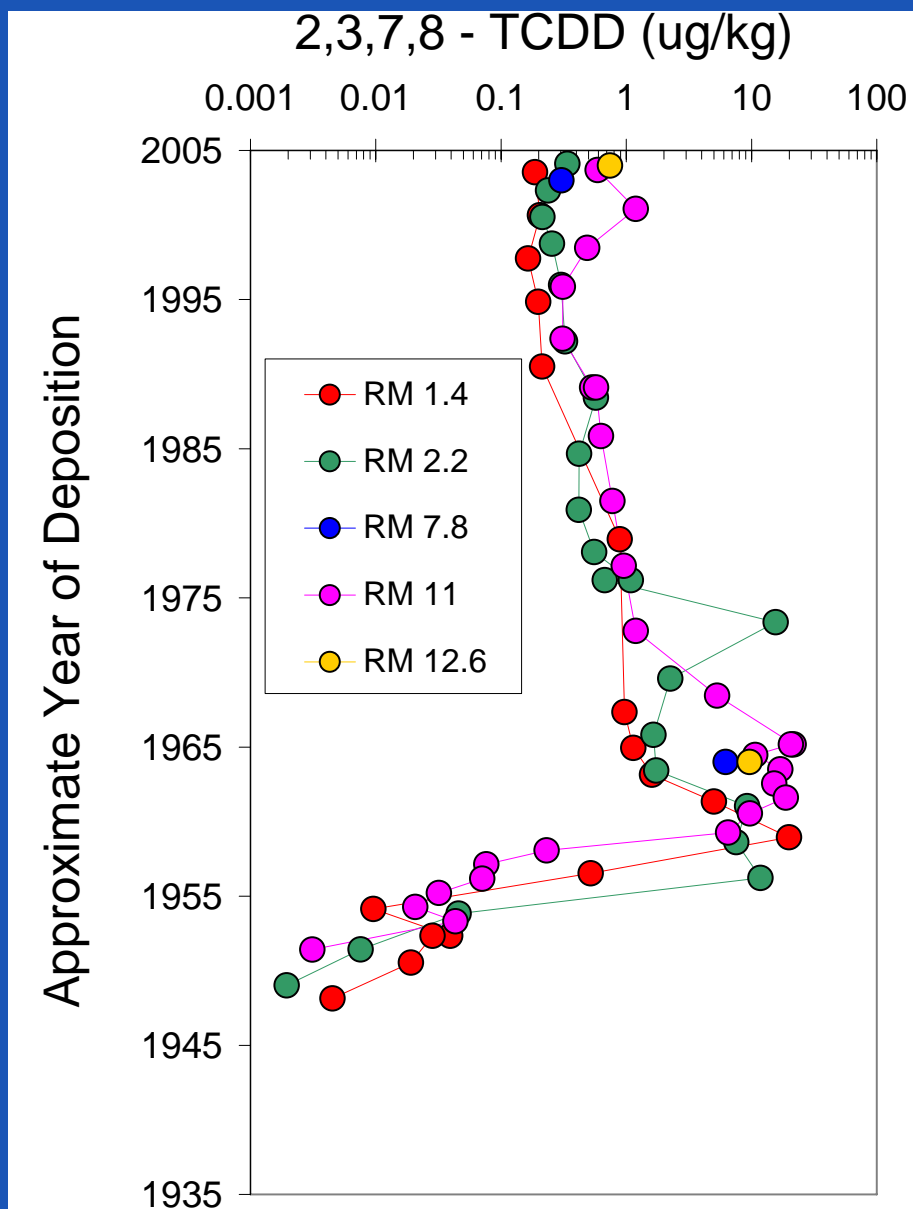


Depositional and Erosional Areas

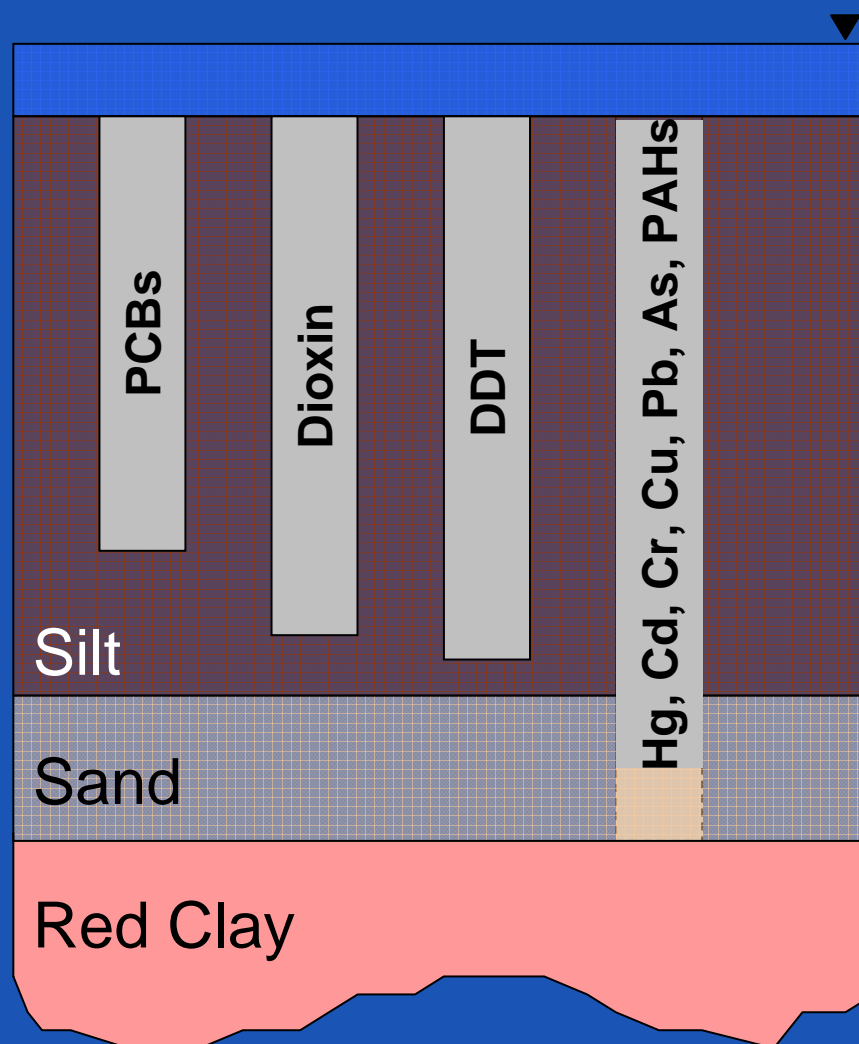
Physical Setting



The History of Contamination is Recorded in the Sediments

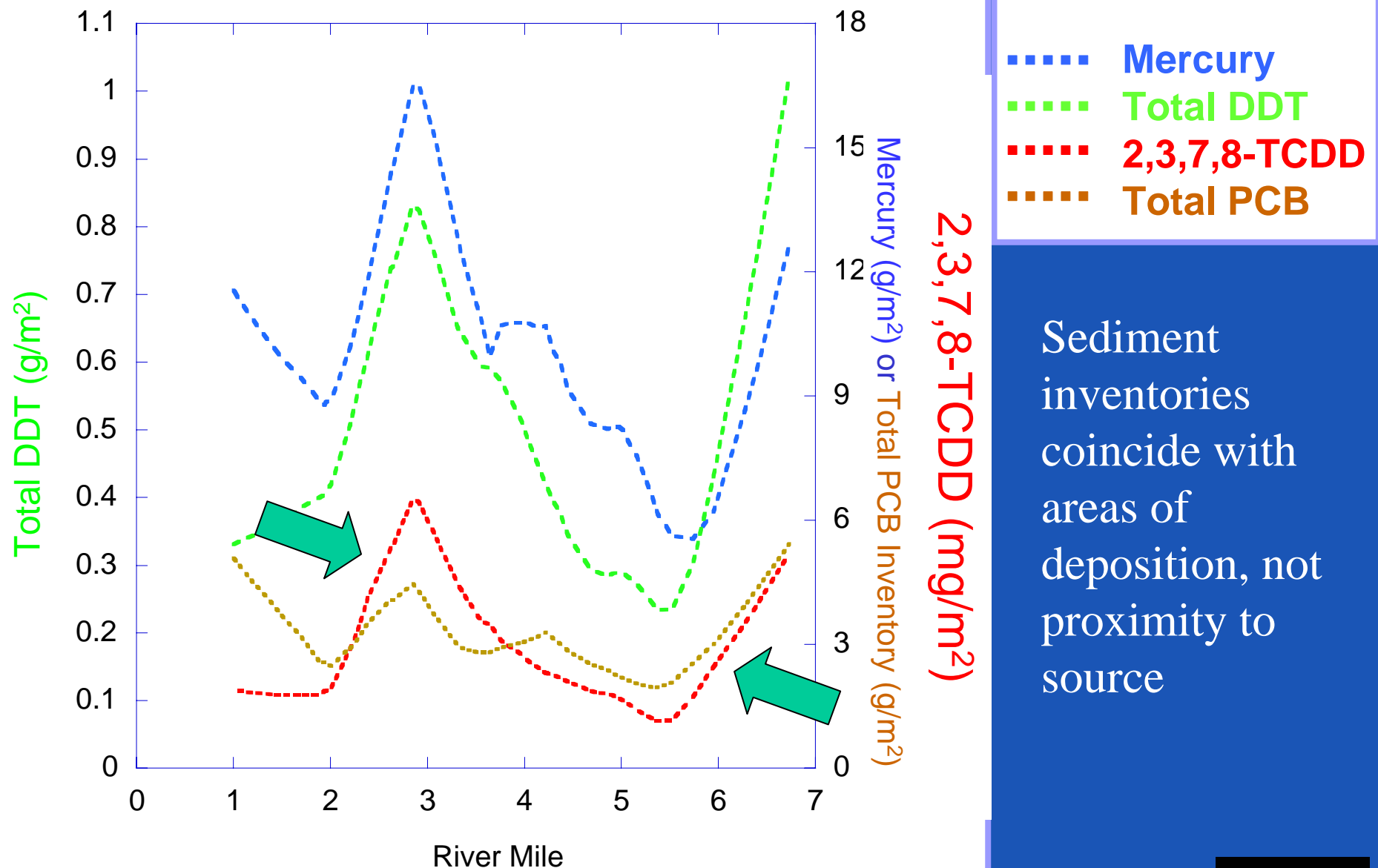


Contaminant Inventory in the Lower Passaic River



Inventory Results

Chemical Setting



Sediment inventories coincide with areas of deposition, not proximity to source



Framework of the Empirical Mass Balance Model



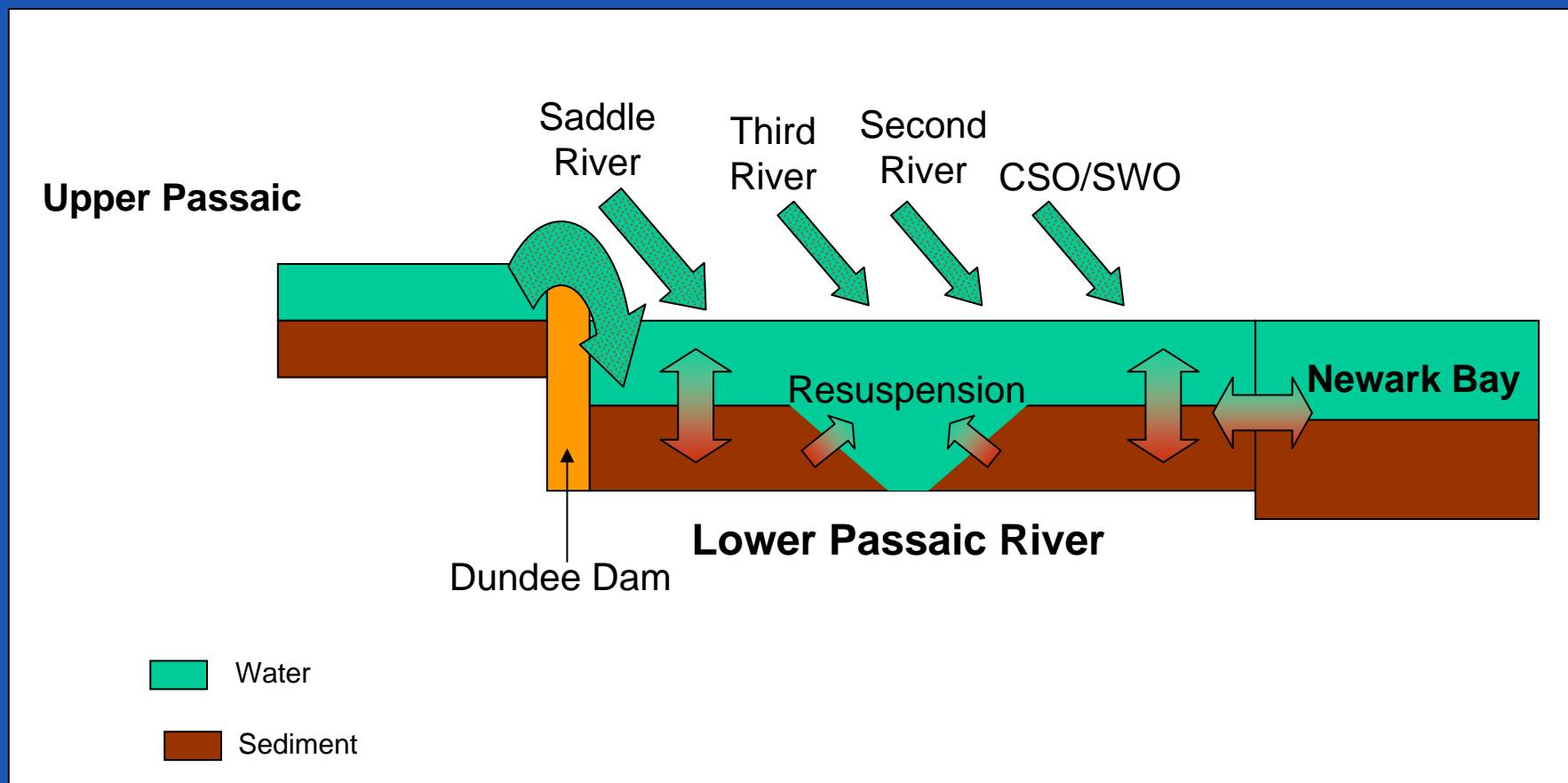
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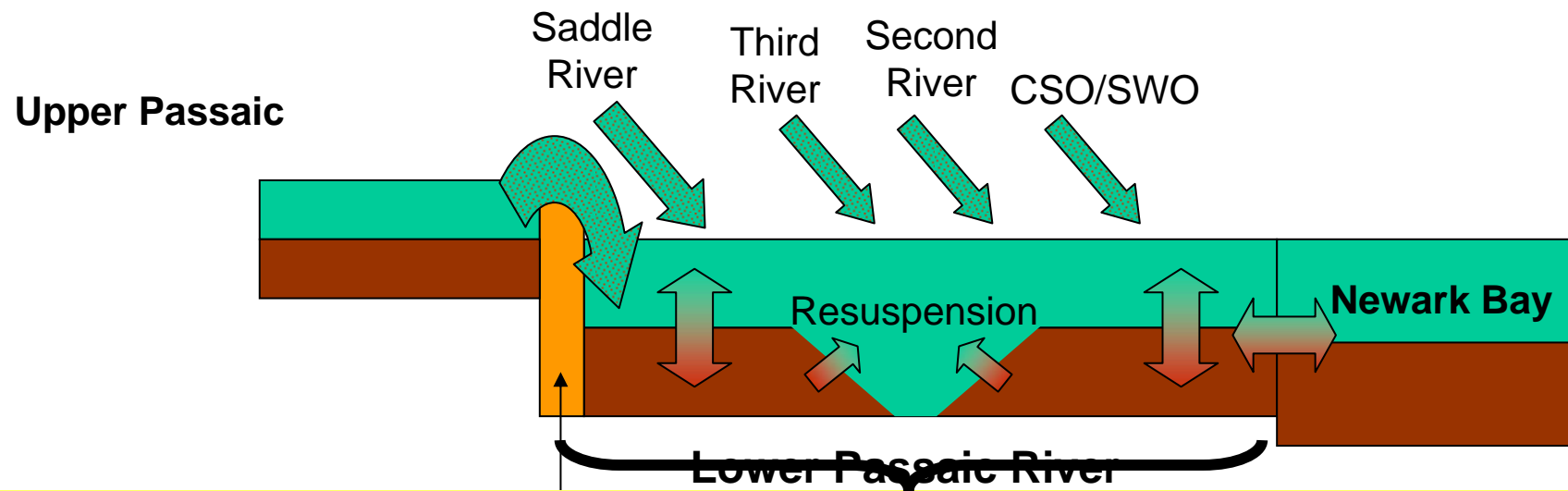
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Schematic of Box Model for the Lower Passaic River Empirical Mass Balance



Schematic of Box Model for the Lower Passaic River Empirical Mass Balance



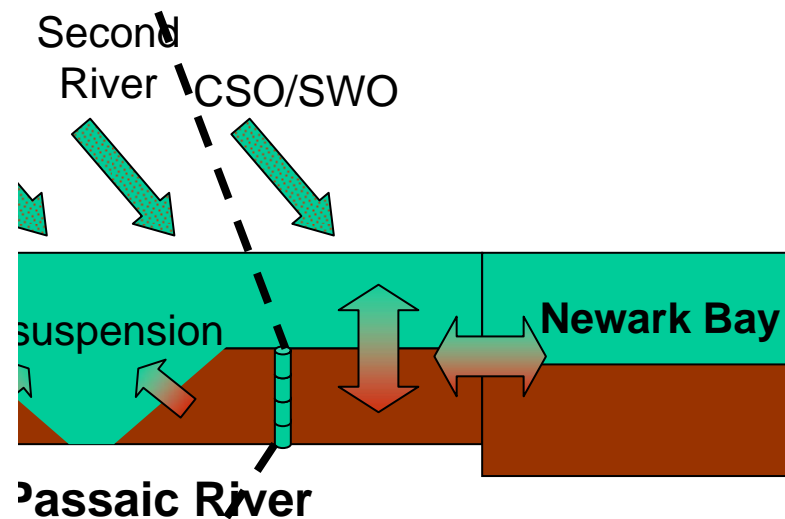
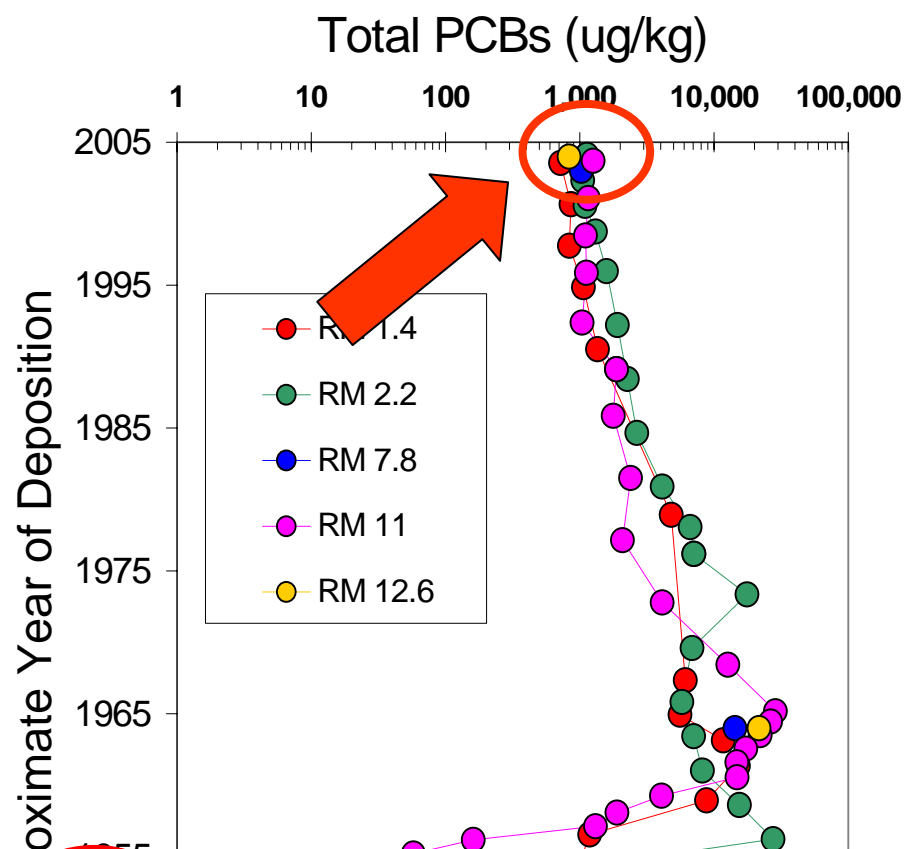
$$C_{surf\ sed} = \frac{f_{DD} * C_{DD} + f_{NB} * C_{NB} + f_{Tribes} * C_{Tribes} + f_{CSO/SWO} * C_{CSO/SWO} + f_{resusp} * C_{resusp}}{f_{DD} + f_{NB} + f_{Tribes} + f_{CSO/SWO} + f_{resusp}}$$

where f_i = fraction of solids from source i

C_i = contaminant concentration in source i



Model for the Lower al Mass Balance



$$C_{surf\ sed} = \frac{f_{DD} * C_{DD} + f_{NB} * C_{NB} + f_{Tribes} * C_{Tribes} + f_{CSO/SWO} * C_{CSO/SWO} + f_{resusp} * C_{resusp}}{f_{DD} + f_{NB} + f_{Tribes} + f_{CSO/SWO} + f_{resusp}}$$

where f_i = fraction of solids from source i

C_i = contaminant concentration in source i



Contaminants Used in the EMBM

- Metals
 - Lead
 - Mercury
- PCDD/F
 - 2,3,7,8-TCDD
 - Total TCDD
- Pesticides
 - DDE
- PAHs
 - Benzo[a]pyrene
 - Fluoranthene
- PCB Congeners
 - BZ 52
 - BZ 180+193



Formulation for the EMBM

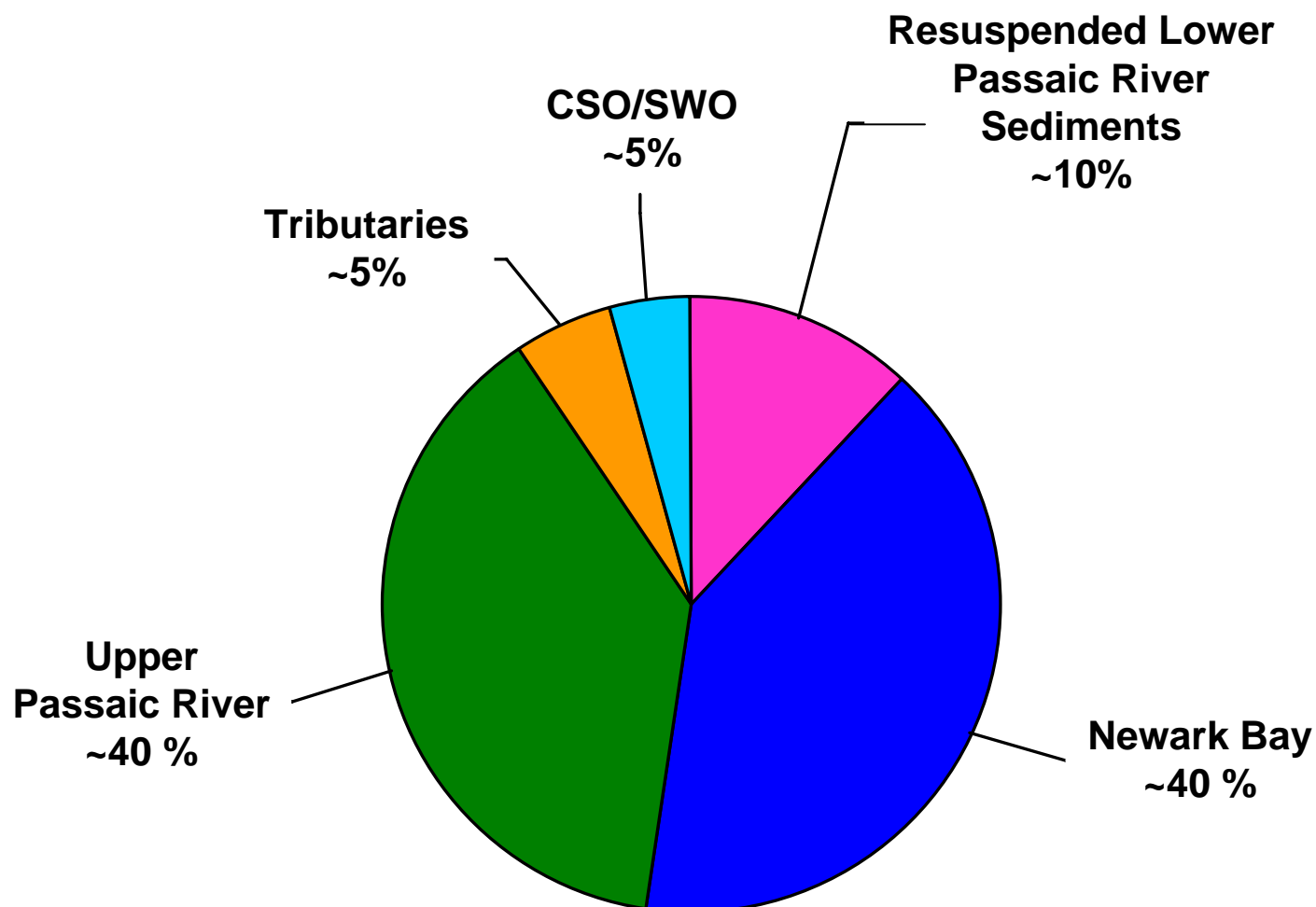
- Five unknowns + 1
 - f_{DD} to f_{resusp}
 - C_{resusp} narrowly constrained by range of sediment conditions
- Nine equations
 - One for each of nine contaminants
- Solve by optimization
 - Minimize overall level of error for all five unknowns for given C_{resusp}



Empirical Mass Balance Model Results

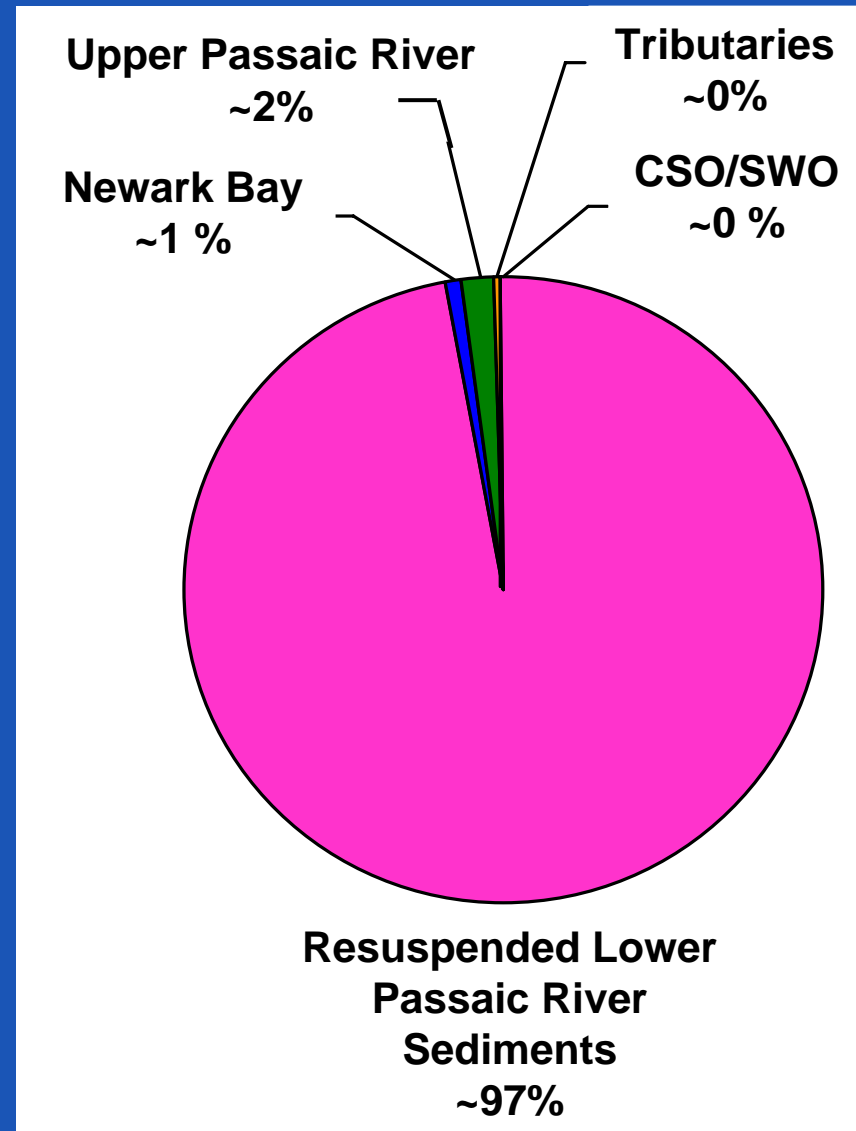


Solids Balance for the Lower Passaic River: External Solids Dominant

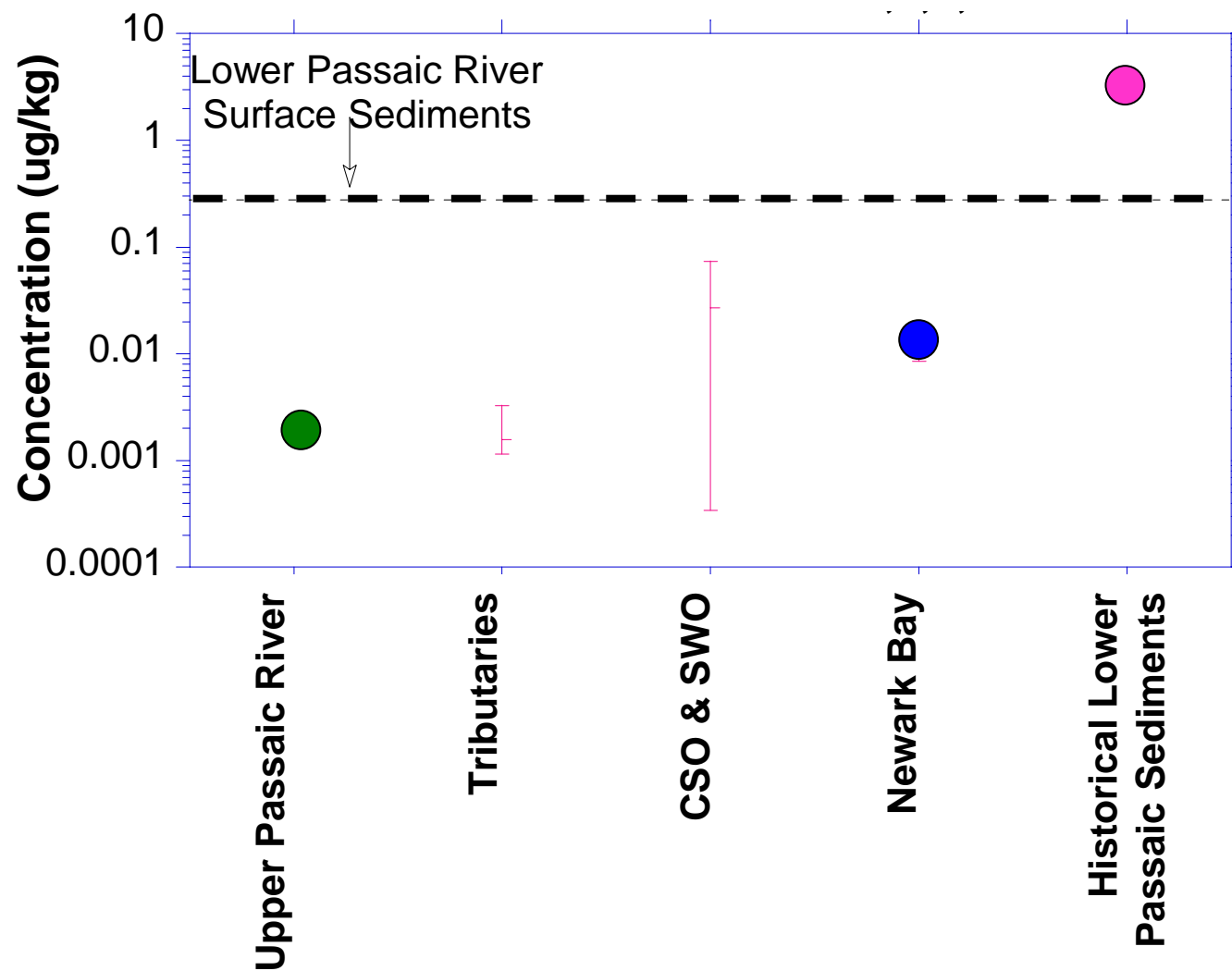


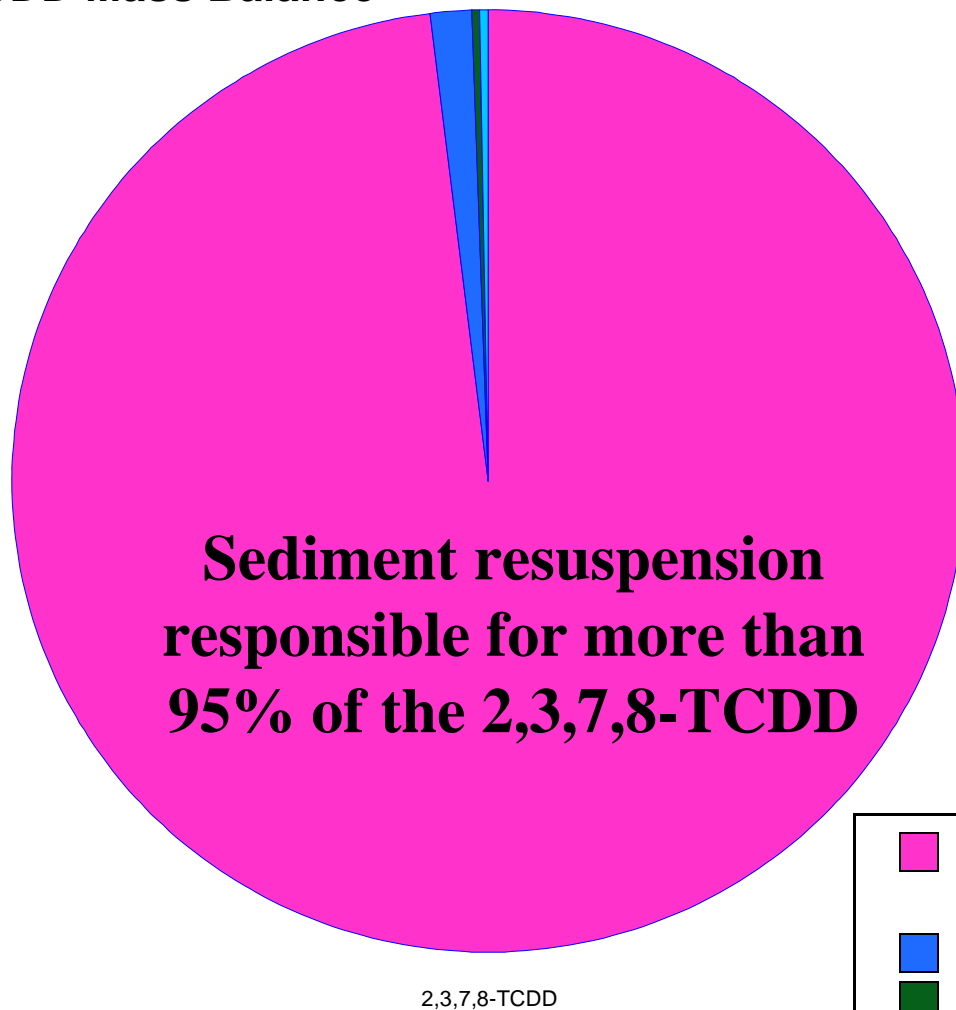
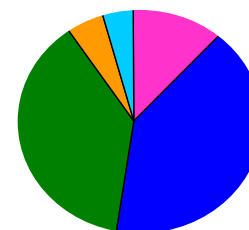
Solids Balance for the Lower Passaic River: Internal Solids Dominant

EMBM

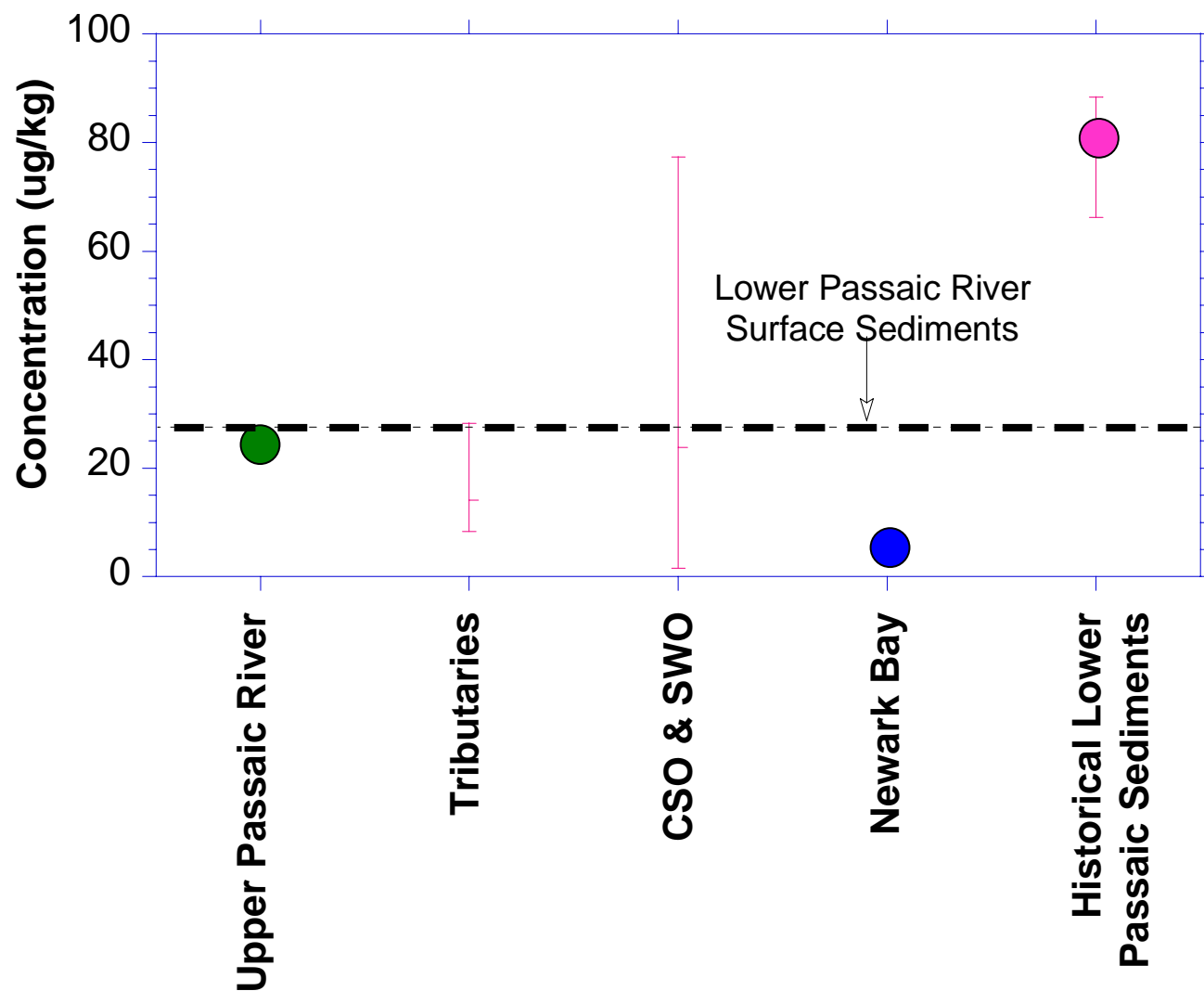


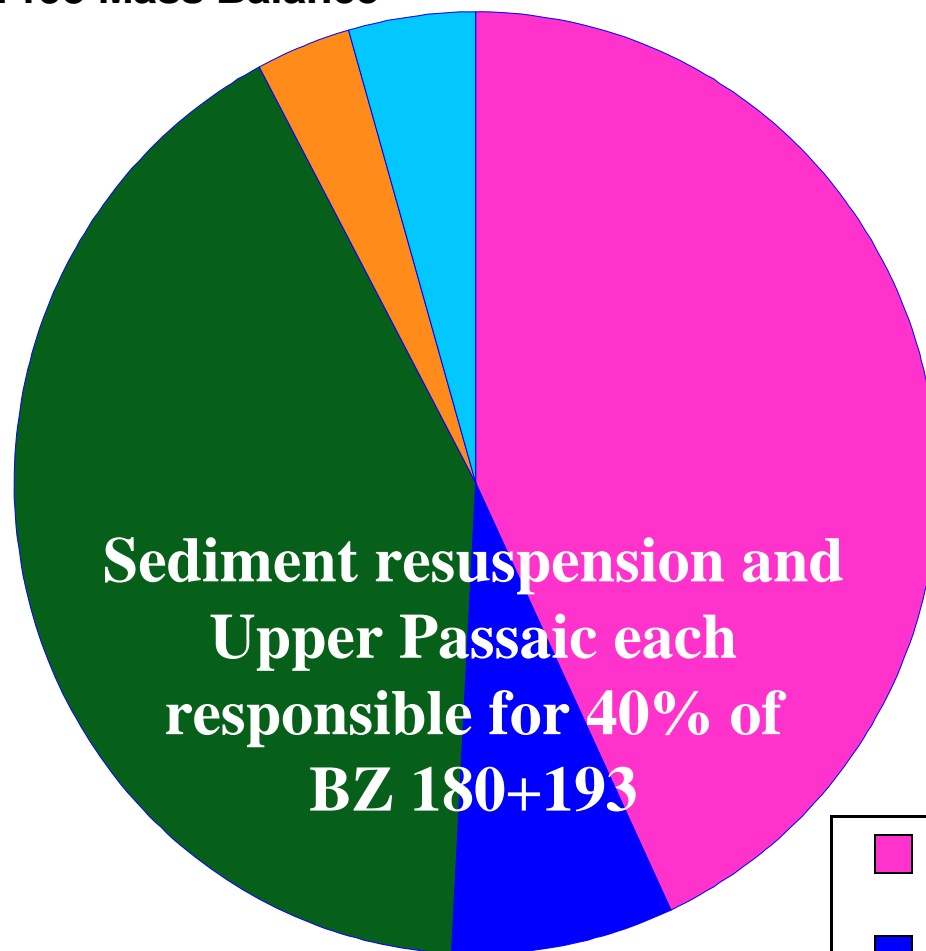
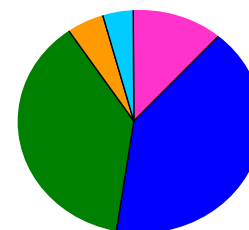
Source Concentrations for 2,3,7,8-TCDD



2,3,7,8-TCDD Mass Balance**Solids Balance****Similar Compounds****Total TCDD****Light PCBs**

Source Concentrations for PCBs BZ180+193



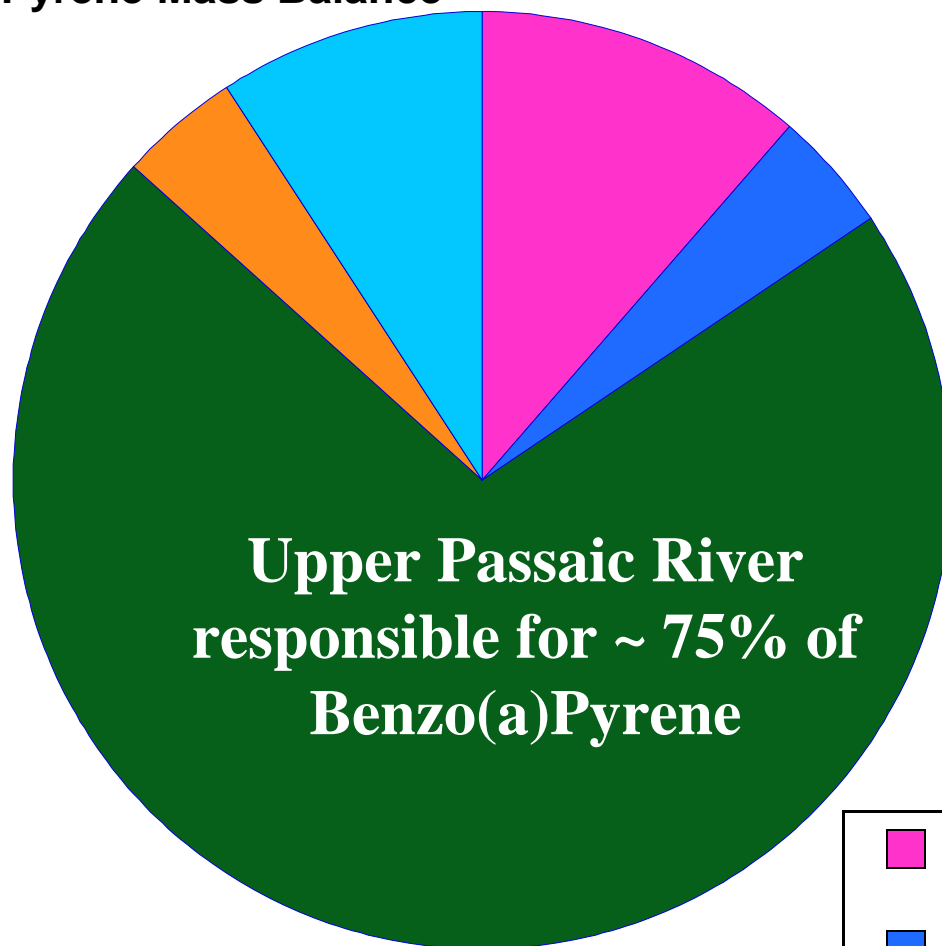
PCB BZ180+193 Mass Balance**Solids Balance****Similar Compounds**

**Heavy PCBs
DDTs
Mercury**

- Historical Lower Passaic Sediments
- Newark Bay
- Upper Passaic
- Tributaries
- CSO&SWO



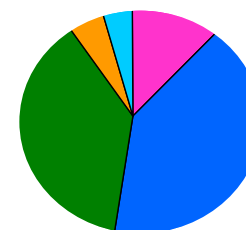
Benzo(a)Pyrene Mass Balance



Benzo(a)pyrene



Solids Balance

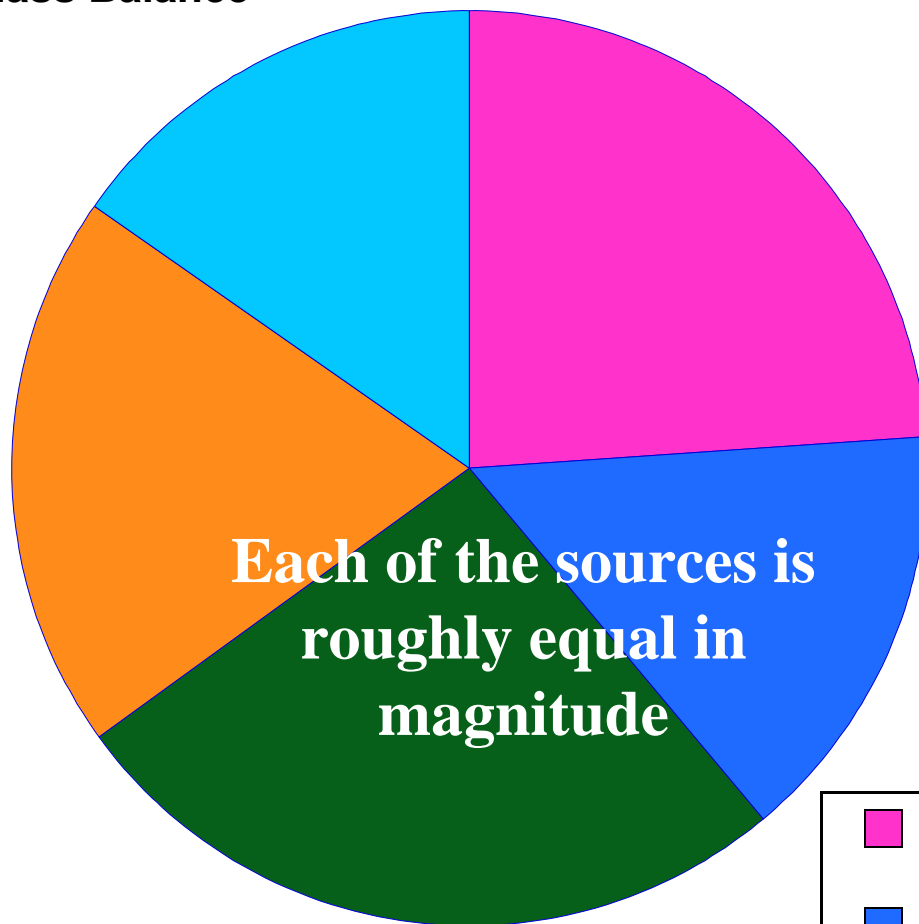


Similar Compounds

LMW PAHs
HMW PAHs



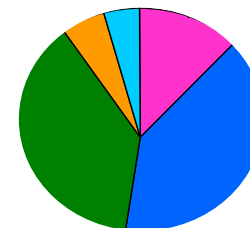
Lead Mass Balance



Lead

- Historical Lower Passaic Sediments
- Newark Bay
- Upper Passaic
- Tributaries
- CSO&SWO

Solids Balance



Similar Compounds

Copper
Chlordane
Dieldrin



The Historical Record and Remedial Scenario Forecasts



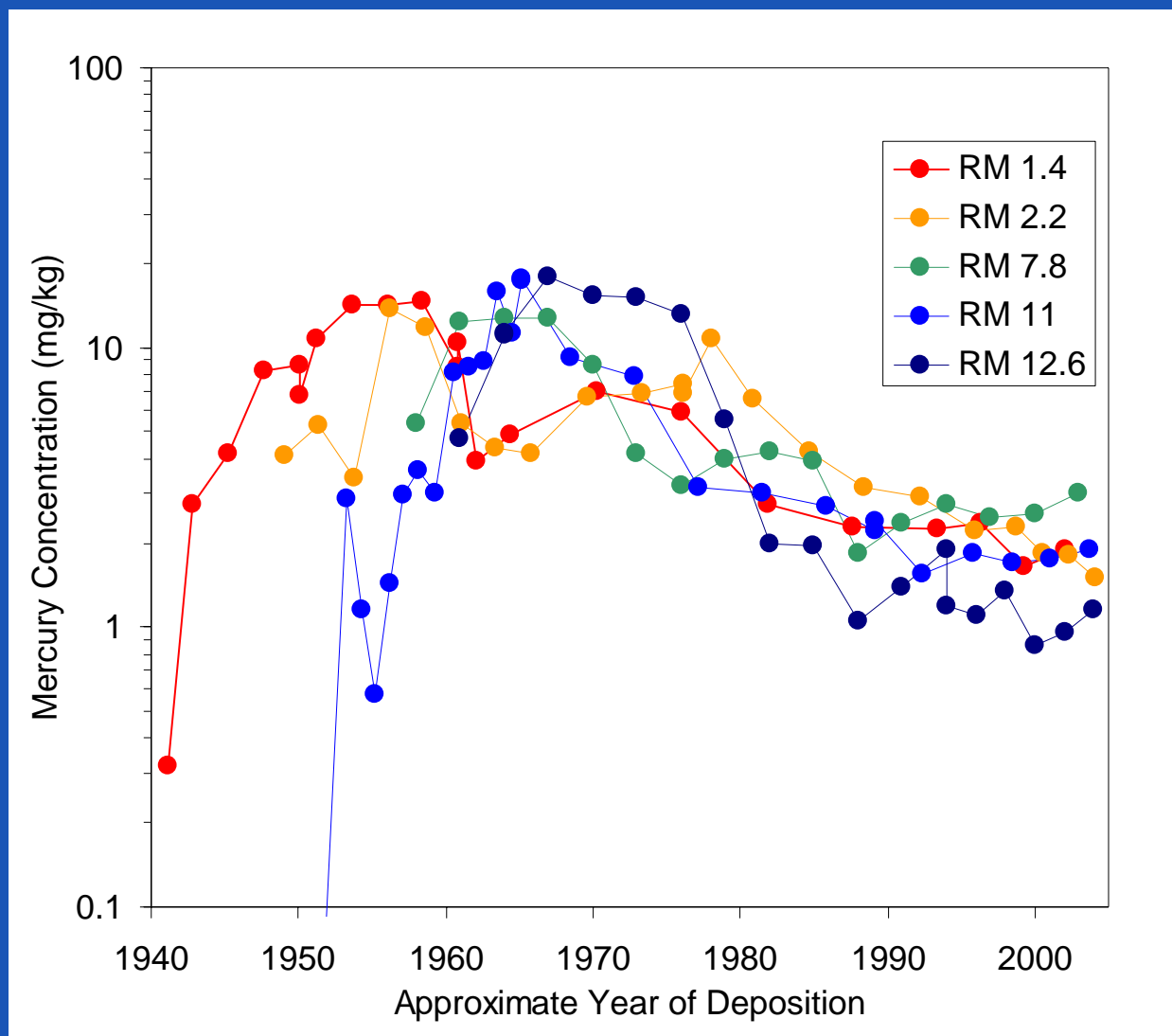
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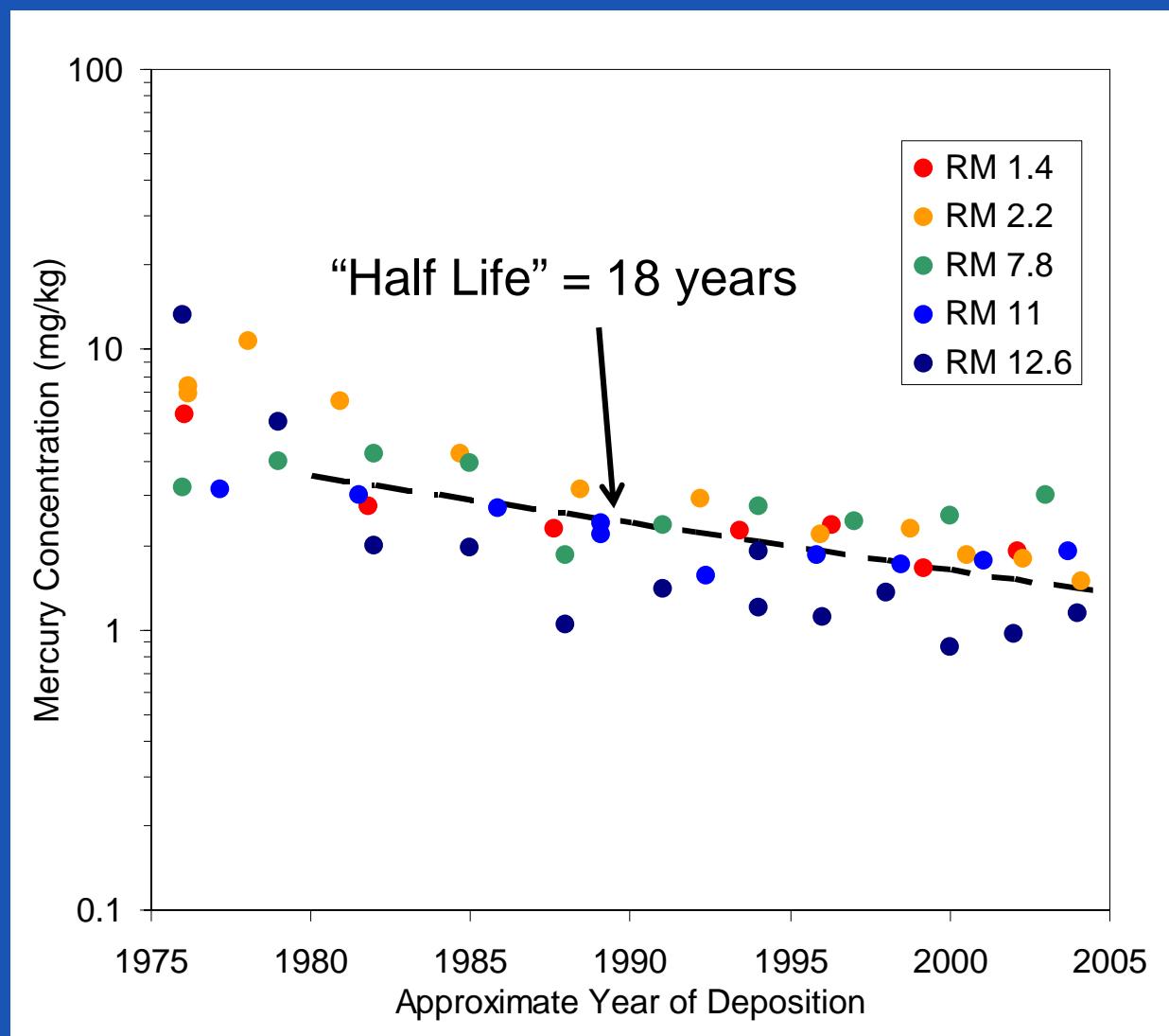
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Basis for Forecasts: Dated Cores



Basis for Forecasts: Dated Cores



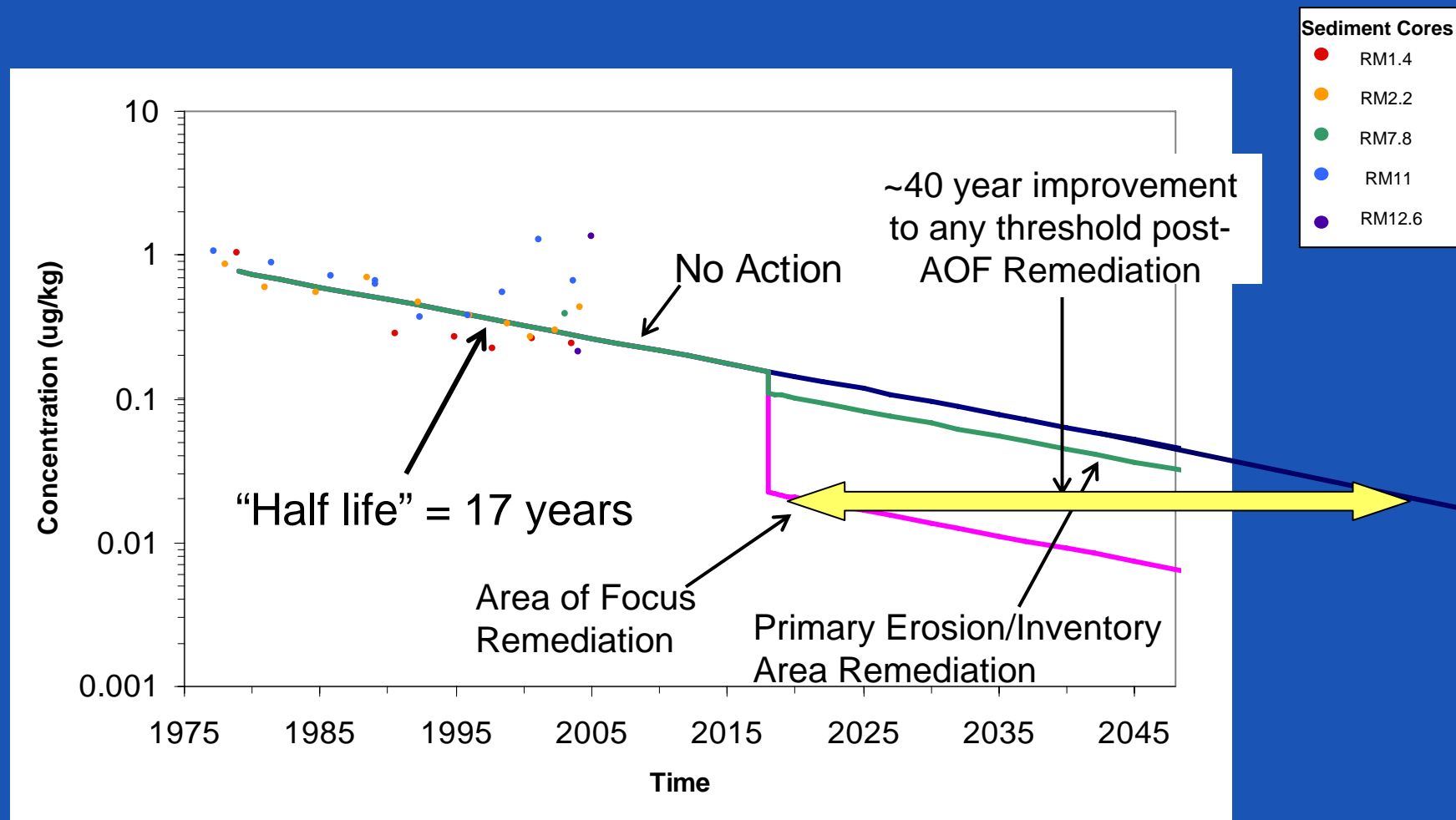
Remedial Scenarios

- No Action
- Primary Erosion/
Inventory Area
Remediation
- Area of
Focus
Remediation



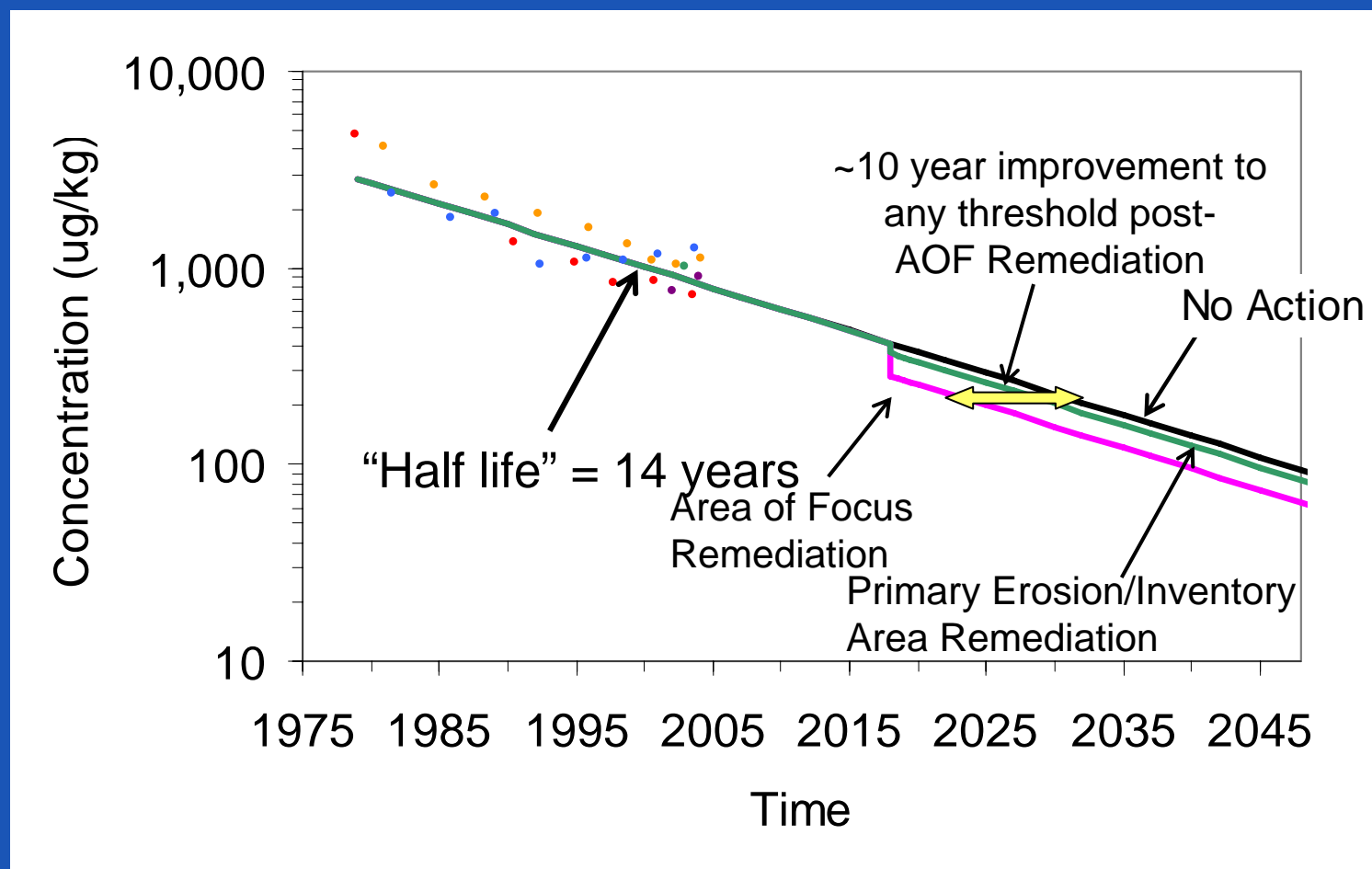
2,3,7,8-TCDD

Forecasted Surface Sediment Concentrations



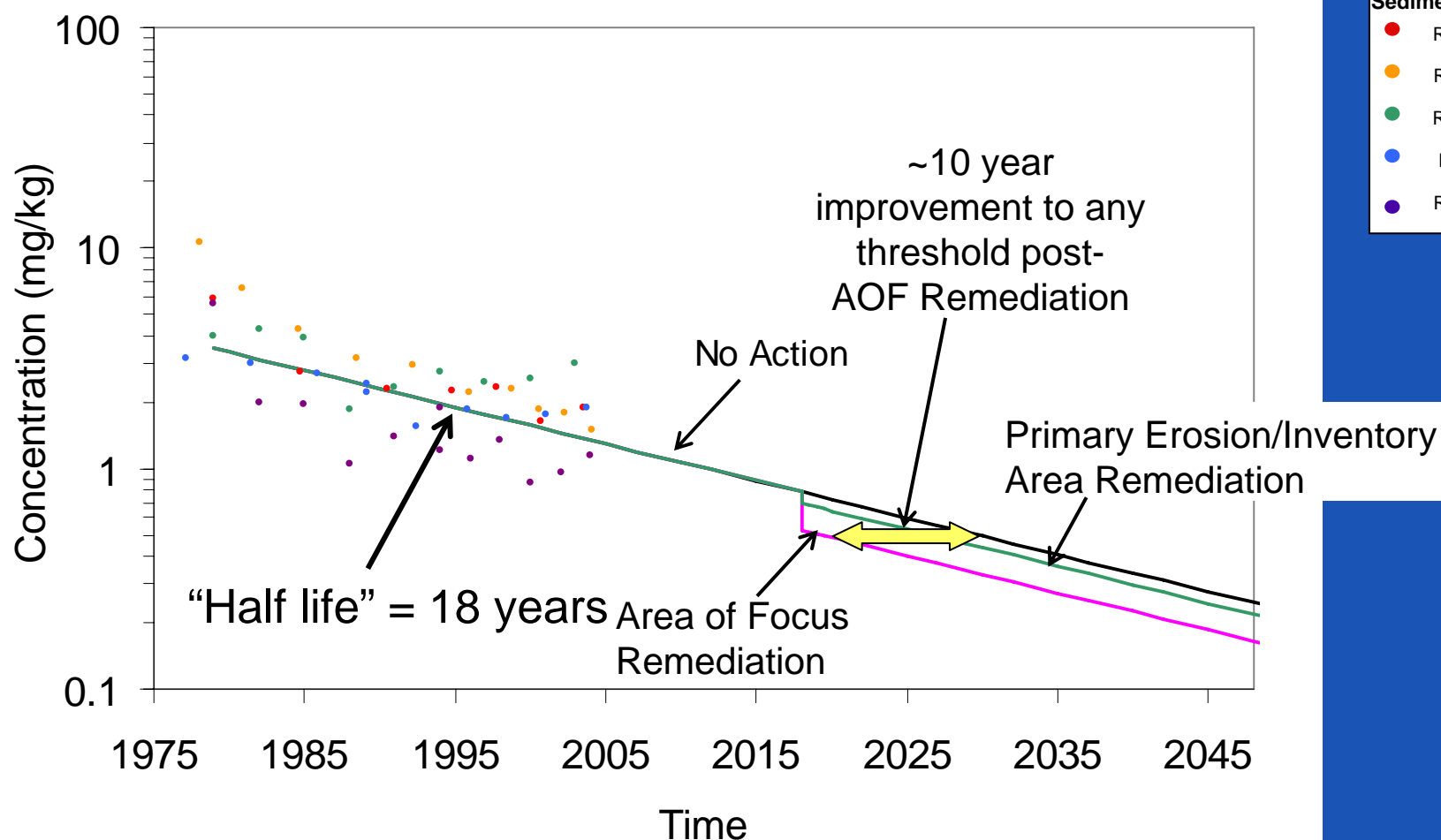
Total PCBs

Forecasted Surface Sediment Concentrations



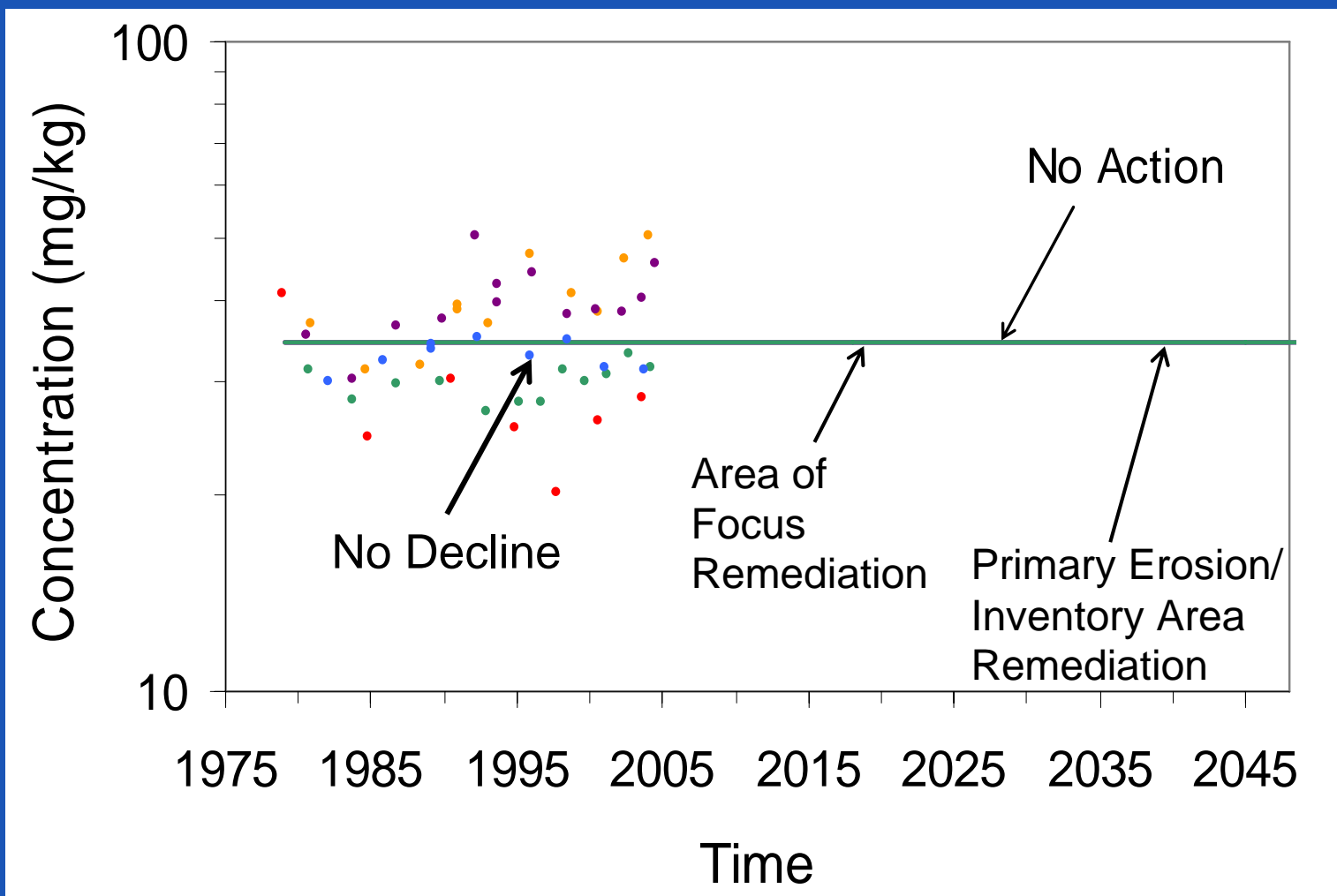
Mercury

Forecasted Surface Sediment Concentrations



High Molecular Weight PAHs

Forecasted Surface Sediment Concentrations



Conclusions of the EMBM

- External contaminant sources (by themselves) cannot account for the observed COPC concentrations.
- Sediment re-suspension is a major contributor to the contaminant burden of recently deposited sediments.
- Surface sediments originate from the Upper Passaic River and Newark Bay in roughly equal proportions.
 - Minor **solids** contributions from historical sediment re-suspension, tributaries, and CSO/SWOs.
- CSO/SWOs and the tributaries play lesser roles for most contaminants.¹
 - More important for lead, dieldrin, chlordane and copper¹

1. These bullets were modified from the original presentation to be more consistent with the oral presentation and the EMBM report.



Conclusions of the EMBM (cont.)

- Re-suspension of legacy sediments (*i.e.*, the historical inventory) =
 - ~10 percent of the total annual solids deposition
 - >95% of annual 2,3,7,8-TCDD load
 - Single largest source of :
 - PCBs
 - DDT+DDE+DDD
 - Mercury
- Upper Passaic River is the major source of PAHs and an important source of PCBs and mercury
- Newark Bay solids serve to dilute contamination in Lower Passaic River sediments.
 - Newark Bay represents about 25 % of mercury load



Conclusions of the EMBM (cont.)

- Surface sediment concentrations show very slow declines post 1980.
 - Total PCB has shortest half life, at 14 years.
- LMW PAHs, HMW PAHs, and dieldrin have not declined since 1980 and may be increasing slightly with time.
- Remediation of the Area of Focus of can significantly reduce future surface concentrations of dioxin, reducing the recovery time by ~40 years relative to No Action.
- Remediation of the Area of Focus can also improve surface concentrations of PCBs, DDT, and mercury, but to a lesser degree, improving recovery by ~10 to 15 years relative to No Action.
- Remediation of the Primary Erosion and Primary Inventory Zones results in only marginal improvements relative to No Action.

